

DOCKET NO: 002-US-009

APPLICATION
FOR
UNITED STATES LETTERS PATENT

TITLE: Topic Identification and Use Thereof In
Information Retrieval Systems
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Express Mail No: EL870120418US

Date: 25 February 2002

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TOPIC IDENTIFICATION AND USE THEREOF IN INFORMATION RETRIEVAL SYSTEMS

Background

5 The invention relates generally to computerized information management technologies and, more particularly but not by way of limitation, to the generation of relevant domain-specific topics for a corpus of data to facilitate subsequent search and retrieval operations for the data.

10 It is generally recognized that much of the world economic order is shifting from one based on manufacturing to one based on the generation, organization and use of information. To successfully manage this transition, organizations must collect and classify vast amounts of data so that it may be searched and retrieved in a meaningful manner. Traditional techniques to classify data may be divided into four approaches: (1) manual; (2) unsupervised
15 learning; (3) supervised learning; and (4) hybrid approaches.

 Manual classification relies on individuals reviewing and indexing data against a predetermined list of categories. For example, the National Library of Medicine's MEDLINE® (Medical Literature, Analysis, and Retrieval System Online) database of journal articles uses this approach. While manual approaches benefit
20 from the ability of humans to determine what concepts a data represents, they also suffer from the drawbacks of high cost, human error and relatively low rate of processing. Unsupervised classification techniques rely on computer software to examine the content of data to make initial judgments as to what classification data belongs to. Many unsupervised classification technologies rely on Bayesian
25 clustering algorithms. While reducing the cost of analyzing large data collections, unsupervised learning techniques often return classifications that have no obvious basis on the underlying business or technical aspects of the data. This disconnect between the data's business or technical framework and the derived classifications make it difficult for users to effectively query the resulting
30 classifications. Supervised classification techniques attempt to overcome this

drawback by relying on individuals to "train" the classification engines so that derived classifications more closely reflect what a human would produce.

Illustrative supervised classification technologies include semantic networks and neural networks. While supervised systems generally derive classifications more attuned to what a human would generate, they often require substantial training and tuning by expert operators and, in addition, often rely for their results on data that is more consistent or homogeneous than is often possible to obtain in practice. Hybrid systems attempt to fuse the benefits of manual classification methods with the speed and processing capabilities employed by unsupervised and supervised systems. In known hybrid systems, human operators are used to derive "rules of thumb" which drive the underlying classification engines.

No known data classification approach provides a fast, low-cost and substantially automated means to classify large amounts of data that is consistent with the semantic content of the data itself. Thus, it would be beneficial to provide a mechanism to determine a collection of topics that are explicitly related to both the domain of interest and the data corpus analyzed.

Summary

In one embodiment the invention provides a method to identify topics in a data corpus. The method includes determining a segment-level actual usage value for one or more word combinations, computing a segment-level expected usage value for each of the one or more word combinations, and designating a word combination as a topic if the segment-level actual usage value of the word combination is significantly greater than the segment-level expected usage value of the word combination.

In another embodiment, the invention provides a method to display a list of topics associated with stored data items. The method includes, identifying a result set based on an initial user query, identifying those topics associated with the stored data items identified in the result set, selecting for display a topic associated with the most identified stored data items, selecting for display

another topic associated with the most identified stored data items not already associated with a previously identified display topic, and displaying the selected display topics. Wherein the act of selecting for display another topic is repeated until all, or a specified number, of the identified stored items have been
 5 accounted for in the displayed topics.

In yet other embodiments, the invention provides devices and systems to perform one or more of the afore-mentioned methods.

Brief Description of the Drawings

10 Figure 1 shows, in flowchart form, a method to identify topics in a corpus of data in accordance with one embodiment of the invention.

Figure 2 shows, in flowchart form, a method to generate a domain specific word list in accordance with one embodiment of the invention.

15 Figure 3 shows, in flowchart form, a method to identify topics in a corpus of data in accordance with one embodiment of the invention.

Figure 4 shows, in flowchart form, a method to measure actual usage of significant words in a corpus of data in accordance with one embodiment of the invention.

20 Figure 5 shows, in flowchart form, a topic refinement process in accordance with one embodiment of the invention.

Figures 6 shows, in flowchart form, a topic identification method in accordance with one embodiment of the invention.

Figure 7 shows, in flowchart form, one method in accordance with the invention to identify those topics for display during a user query operation.

25 Figure 8 shows, in block diagram form, a system in accordance with one embodiment of the invention.

Detailed Description

30 Techniques (methods and devices) to generate domain specific topics for a corpus of data are described. Other techniques (methods and devices) to

associate the generated topics with individual documents, or portions thereof, for use in electronic search actions are also described. The following embodiments of the inventive techniques are illustrative only and are not to be considered limiting in any respect.

5 In one embodiment of the invention, a collection of topics is determined for a first corpus of data, wherein the topics are domain specific, based on a statistical analysis of the first data corpus and substantially automatically generated. In another embodiment of the invention, the topics may be associated with each "segment" of a second corpus of data, wherein a segment
10 is a user-defined quantum of information. Example segments include, but are not limited to, sentences, paragraphs, headings (e.g., chapter headings, titles of manuscripts, titles of brochures and the like), chapters and complete documents. Data comprising the data corpus may be unstructured (e.g., text) or structured (e.g., spreadsheets and database tables). In yet another embodiment of the
15 invention, topics may be used during user query operations to return a result set based on a user's query input.

Referring to FIG. 1, one method in accordance with the invention uses domain specific word list **100** as a starting point from which to analyze data **105** (block **110**) to generate domain specific topic list **115**. Once generated, topic list
20 **115** entries may be associated with each segment of data **105** (block **120**) and stored in database **125** where it may be queried by user **135** through user interface **130**. Word list **100** may comprise a list of words or word combinations that are meaningful to the domain from which data **105** is drawn. For example, if data **105** represents medical documents then word list **100** may be those
25 words that are meaningful to the medical field or those subfields within the field of medicine relevant to data **105**. Similarly, if data **105** is drawn from the accounting, corporate governance or the oil processing and refining business, word list **100** will comprise words that hold particular importance to those fields. Data **105** may be substantially any form of data, structured or unstructured. In
30 one embodiment, data **105** comprises unstructured text files such as medical

abstracts and/or articles. In another embodiment, data **105** comprises books, newspapers, magazine content or a combination of these sources. In still another embodiment, data **105** comprises structured data such as design documents and spreadsheets describing an oil refinery process. In yet other embodiments, data

5 **105** comprises content tagged image data, video data and/or audio data. In still another embodiment, data **105** comprises a combination of structured and unstructured data.

Acts in accordance with block **110** use word list **100** entries to statistically analyze data **105** on a segment-by-segment basis. In one embodiment, a

10 segment may be defined as a sentence and/or heading and/or title. In another embodiment, a segment may be defined as a paragraph and/or heading and/or title. In yet another embodiment, a segment may be defined as a chapter and/or heading and/or title. In still another embodiment, a segment may be defined as a complete document and/or heading and/or title. Other definitions may be

15 appropriate for certain types of data and, while different from those enumerated here, would be obvious to one of ordinary skill in the art. For example, headings and titles may be excluded from consideration. It is noted that only a portion of data **105** need be analyzed in accordance with block **110**. That is, a first portion of data **105** may be used to generate topic list **115**, with the topics so identified

20 being associated with the entire corpus of data during the acts of block **120**.

Table 1. Example Data

By way of example only, in one embodiment data **105** comprises the text of approximately 12 million abstracts from the Medline® data collection. These abstracts include approximately 2.8 million unique words, representing approximately 40 Gigabytes of raw data.

MEDLINE® (Medical Literature, Analysis, and Retrieval System Online) is the U.S. National Library of Medicine's (NLM) bibliographic database of

Table 1. Example Data

journal articles covering basic biomedical research and the clinical sciences including: nursing, dentistry, veterinary medicine, pharmacy, allied health, pre-clinical sciences, environmental science, marine biology, plant and animal science, biophysics and chemistry. The database contains bibliographic citations and author abstracts from more than 4,600 biomedical journals published in the United States and 70 other countries. Medline® is searchable at no cost from the NLM's web site at <http://www.nlm.nih.gov>.

Referring to FIG. 2, in one embodiment of the invention word list **100** may be generated by first compiling a preliminary list of domain specific words **200** and then pruning from that list those entries that do not significantly and/or uniquely identify concepts or topics within the target domain (block **205**).

Preliminary list **200** may, for example, be comprised of words from a dictionary, thesaurus, glossary, domain specific word list or a combination of these sources. For example, the Internet may be used to obtain preliminary word lists for virtually any field. Words removed in accordance with block **205** may include standard STOP words as illustrated in Table 2. (One of ordinary skill in the art will recognize that other STOP words may be used.) In addition, it may be beneficial to remove words from preliminary word list **200** that are not unique to the target domain. For example, while the word "reservoir" has a particular meaning in the field of oil and gas development, it is also a word of common use. Accordingly, it may be beneficial to remove this word from a word list specific to the oil and gas domain. In one embodiment, a general domain word list may be created that comprises those words commonly used in English (or another language), including those that are specific to a number of different domains. This "general word list" may be used to prune words from a preliminary domain specific word list. In another embodiment, some common words removed as a result of the general word list pruning just described may be

added back into preliminary word list **200** because, while used across a number of domains, have a particular importance in the particular domain.

Table 2. Example Stop Words

a, about, affect, after, again, all, along, also, although, among, an, and, another, any, anything, are, as, at, be, became, because, been, before, both, but, by, can, difference, each, even, ever, every, everyone, for, from, great, had, has, have, having, he, hence, here, his, how, however, I, if, in, inbetween, into, is, it, its, join, keep, last, lastly, let, many, may, me, more, most, much, next, no, none, not, nothing, now, of, on, only, or, other, our, pause, quickly, quietly, relationship, relatively, see, she, should, since, so, some, somebody, someone, something, sometimes, successful, successfully, such, take, than, that, the, their, there, these, they, this, those, thus, to, unusual, upon, us, use, usual, view, was, we, went, what, when, whence, where, whether, which, while, who, whose, will, with, within, without, yes, yet, you, your

Table 3. Example Word List

For the data set identified in Table 1, preliminary word list **200** was derived from the Unified Medical Language System Semantic Network (see <http://www.nlm.nih.gov/databases/leased.html#umls>) and included 4,000,000 unique single-word entries. Of these, roughly 3,945,000 were removed in accordance with block **205**. Accordingly, word list **100** comprised approximately 55,000 one word entries.

Example word list **200** entries for the medical domain include:

abdomen, biotherapy, chlorided, distichiasis, enzyme, enzymes, freckle, gustatory, immune, kyphoplasty, laryngectomy, malabsorption, nebulizer, obstetrics, pancytopenia, quadriparesis, retinae, sideeffect, tonsils, unguium, ventricular, womb, xerostomia, yersinia, and zygote.

Conceptually, word list **100** provides an initial estimation of domain specific concepts/topics. Analysis in accordance with the invention beneficially expands the semantic breadth of word list **100**, however, by identifying word collections (e.g., pairs and triplets) as topics (i.e., topic list **115**). Once topics are identified, each segment in data **105** may be associated with those topics (block **120**) that exist in that segment. Accordingly, if a corpus of data comprises information from a plurality of domains, analysis in accordance with FIG. 1 may be run multiple times - each time with a different word list **100**. (Alternatively, each segment may be analyzed for each domain list before a next segment is analyzed.) In this manner, undifferentiated data (i.e., data not identified as belonging to one or another specific domain) may be automatically analyzed and "indexed" with topics. It is noted that word list **100** may be unique for each target domain but, once developed, may be used against multiple data collections in that field. Thus, it is beneficial to refine the contents of word list **100** for each domain so as to make the list as domain-specific as possible. It has been empirically determined that tightly focused domain-specific word lists yield a more concise collection of topics which, in turn, provide improved search results (see discussion below).

Figure 3 illustrates one method in accordance with the invention to identify topics (block **110** of FIG. 1) in data **105** using word list **100** as a starting point. Initially, data **105** (or a portion thereof) is analyzed on a segment-by-segment basis to determine the actual usage of significant words and word combinations (block **300**). A result of this initial step is preliminary topic list **305**. Next, an expected value for each entry in preliminary topic list **305** is computed (block **310**) and compared with the actual usage value determined during block **300** (block **315**). If the measured actual usage of a preliminary topic list entry is significantly greater than the computed expected value of the entry (the "yes" prong of block **315**), that entry is added to topic list **115** (block **320**). If the measured actual usage of a preliminary topic list entry is

not significantly greater than the computed expected value of the entry (the "no" prong of block **315**), that entry is not added to topic list **115**. The acts of blocks **315** and **320** are repeated (the "no" prong of block **325**) until all preliminary topic list **305** entries have been reviewed (the "yes" prong of block **325**).

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Table 4. Example Topic List

For the data set identified in Tables 1 and 3, 10 of the 35 Gigabytes were used to generate topic list **115**. In accordance with FIG. 3, topic list **115** comprised approximately 506,000 entries. In one embodiment, each of these entries are double word entries.

Illustrative topics identified for Medline[®] abstract content in accordance with the invention include: adenine nucleotide, heart disease, left ventricular, atria ventricles, heart failure, muscle, heart rate, fatty acids, loss bone, patient case, bone marrow, and arterial hypertension.

As shown in FIG. 4, one method to measure the actual usage of significant words in data **105** (block **300**) is to determine three statistics for each entry in word list **100**: S1 (block **400**); S2 (block **405**); and S3 (block **410**). In general, statistics S1, S2 and S3 measure the actual frequency of usage of various words and word combinations in data **105** at the granularity of the user-defined segment. More specifically:

- Statistic S1 (block **400**) is a segment-level frequency count for each entry in word list **100**.
 - For example, if a segment is defined as a paragraph, then the value of S1 for word-i is the number of unique paragraphs in data **105** in which word-i is found.
 - An S1 value may also be computed for non-word list **100** words if they are identified as part of a word combination as described below with respect to statistic S2.

- Statistic S2 (block **405**) is a segment-level frequency count for each significant word combination in data **105**. Those word combinations having a non-zero S2 value may be identified as preliminary topics **305**. In one embodiment, a “significant word combination” comprises any two entries in word list **100** that are in the same segment. In another embodiment, a “significant word combination” comprises any two entries in word list **100** that are in the same segment and contiguous. In still another embodiment, a “significant word combination” comprises any two entries in word list **100** that are in the same segment and contiguous or separated only by one or more STOP words. In yet another embodiment, a “significant word combination” comprises any two words that are in the same segment and contiguous or separated only by one or more STOP words where at least one of the words in the word combination is in word list **100**. In general, a “significant word combination” comprises any two or more words that are in the same segment and separated by ‘N’ or fewer specified other words: N may be zero or more; and the specified words are typically STOP words. As a practical matter, word combinations comprising non-word list **100** words may be ignored if they appear in less than a specified number of segments in data **105** (e.g., less than 10 segments).

 - For example, if a segment is defined as a paragraph, then the value of S2 for word-combination-i is the number of unique paragraphs in data **105** in which word-combination-i is found.
- Statistic S3 (block **410**) indicates the number of unique word combinations (identified by having non-zero S2 values, for example) each word in word list **100** was found in.

 - For example, if word-z is only a member of word-combination-i, word-combination-j and word-combination-k and the S2 statistic for each of word-combination-i, word-combination-j and word-combination-k is non-zero, then word-z’s S3 value is 3.

One method to compute the expected usage of significant words in data **105** (block **310**) is to calculate the expected value for each preliminary topic list **305** entry based only on its overall frequency of use in data **105**. In one embodiment, the expected value for each word pair in preliminary word list **305** may be computed as follows:

$$\{ S1(\text{word-i}) \times S1(\text{word-j}) \} \div N,$$

where $S1(\text{word-i})$ and $S1(\text{word-j})$ represents the $S1$ statistic value for word-i and word-j respectively, and N represents the total number of segments in the data corpus being analyzed. One of ordinary skill in the art will recognize that the equation above may be easily extended to word combinations have more than two words.

Referring again to FIG. 3, with measured and computed usage values it is possible to determine which entries in preliminary topic list **305** are suitable for identifying topics within data **105**. In one embodiment, the test (block **315**) of whether a topic's measured usage (block **300**) is significantly greater than the topic's expected usage (block **310**), is a constant multiplier. For example, if the measured usage of preliminary topic list entry-i is twice that of preliminary topic list entry-i's expected usage, preliminary topic list entry-i may be added to topic list **115** in accordance with block **320**. In another embodiment of the invention, if the measured usage of preliminary topic list entry-i is greater than a threshold value (e.g., 10) across all segments, then that preliminary topic list entry is selected as a topic. One of ordinary skill in the art will recognize alternative tests may also be used. For example, a different multiplier may be used (e.g., 1.5 or 3). Additionally, conventional statistical tests of significance may be used.

In one embodiment, topic list **115** may be refined in accordance with FIG. 5. (For convenience, this refinement process will be described in terms of two-word topics. One of ordinary skill in the art will recognize that the technique is equally applicable to topics having more than two words.) As shown, a first two word topic is selected (block **500**). If both words comprising the topic are found in word list **100** (the "yes" prong of block **505**), the two word topic is retained

(block **510**). If both words comprising the topic are not found in word list **100** (the "no" prong of block **505**), but the S3 value for that word which is in word list **100** is not significantly less than the S3 value for the other word (the "yes" prong of block **515**), the two word topic is retained (block **510**). If, on the other hand, one of the topic's words is not in word list **100** (the "no" prong of block **505**) and the S3 value for that word which is in word list **100** is significantly less than the S3 value for the other word (the "no" prong of block **515**), only the low S3 value word is retained in topic list **115** as a topic (block **520**). The acts of blocks **500- 520** are repeated as necessary for each two word topic in topic list **115** (see block **525**). In one embodiment, the test for significance (block **515**) is based on whether the "high" S3 value is in the upper one-third of all S3 values and the "low" S3 value is in the lower one-third of all S3 values. For example, if the S3 statistic for a corpus of data has a range of zero to 12,000, a low S3 value is less then or equal to 4,000 and a "high" S3 value is greater then or equal to 8,000. In another embodiment, the test for significance in accordance with block **515** may be based on quartiles, quintiles or Bayesian tests. Refinement processes such as that outlined in FIG. 5 acknowledge word associations within data, while ignoring individual words that are so prevalent alone (high S3 value) as to offer substantially no differentiation as to content.

Referring again to FIG. 1, once topic list **115** is established, each segment in data **105** may associated with those topics which exist within it (block **120**) and stored in database **125**. Topics may be associated with a data segment in any desired fashion. For example, topics found in a segment may be stored as metadata for the segment. In addition, stored topics may be indexed for improved retrieval performance during subsequent lookup operations. Empirical studies show that the large majority of user queries are "under-defined." That is, the query itself does not identify any particular subject matter with sufficient specificity to allow a search engine to return the user's desired data in a result set (i.e., that collection of results presented to the user) that is acceptably small. A typical user query may be a single word such as, for example, "kidney." In

response to under-defined queries, prior art search techniques generally return large result sets -- often containing thousands, or tens of thousands, of "hits." Such large result sets are almost never useful to a user as they do not have the time to go through every entry to find that one having the information they seek.

5 In one embodiment, topics associated with data segments in accordance with the invention may be used to facilitate data retrieval operations as shown in FIG. 6. When a user query is received (block **600**) it may be used to generate an initial result set (block **605**) in a conventional manner. For example, a literal text search of the query term may identify 100,000 documents (or objects stored in
10 database **125**) that contain the search term. From this initial result set, a subset may be selected for analysis in accordance with topics (block **610**). In one embodiment, the subset is a randomly chosen 1% of the initial result set. In another embodiment, the subset is a randomly chosen 1,000 entries from the initial result set. In yet another embodiment, a specified number of entries are
15 selected from the initial result set (chosen in any manner desired). While the number of entries in the result subset may be chosen in substantially any manner desired, it is preferable to select at least a number that provides "coverage" (in a statistical sense) for the initial result set. In other words, it is desirable that the selected subset mirror the initial result set in terms of topics.
20 With an appropriately chosen result subset, the most relevant topics associated with those results may be identified (block **615**) and displayed to the user (block **620**).

Figure 7 shows one method in accordance with the invention to identify those topics for display (block **615**). Initially, all unique topics associated with
25 the result subset are identified (block **700**), and those topics that appear in more than a specified fraction of the result subset are removed (block **705**). For example, those topics appearing in 80% or more of the segments comprising the result subset may be ignored for the purposes of this analysis. (A percentage higher or lower than this may be selected without altering the salient
30 characteristics of the process.) Next, that topic which appears in the most result

subset entries is selected for display (block **710**). If more than one topic ties for having the most coverage, one may be selected for display in any manner desired. If, after ignoring those result subset entries associated with the selected topic, there remains more than a specified fraction of the result subset (the "yes" prong of block **715**), that topic having the next highest coverage is selected (block **720**). The process of blocks **715** and **720** is repeated until the remaining fraction of result subset entries is at or below the specified threshold. In one embodiment, the specified threshold of block **715** is 20%, although a percentage higher or lower than this may be selected without altering the salient characteristics of the process.

If, after ignoring those result subset entries associated with the selected topic(s), there remains less than a specified fraction of the result subset (the "no" prong of block **715**), the remaining topics are serialized and duplicate words are eliminated (block **725**). That is, topics comprising two or more words are broken apart and treated as single-word topics. Next, that single-word topic that appears in the most result subset entries not already excluded is selected for display (block **730**). As before, if more than one topic ties for having the most coverage, one may be selected for display in any manner desired. If, after ignoring those result subset entries associated with the selected topic, result subset entries remain un-chosen (the "yes" prong of block **735**), that topic having the next highest coverage is selected (block **740**). The process of blocks **735** and **740** is repeated until all remaining result subset entries are selected for display (the "no" prong of block **735**).

The topics identified in accordance with FIG. 7 may be displayed to the user (block **620** in FIG. 6). Thus, data retrieval operations in accordance with the invention return one or more topics which the user may select to pursue or refine their initial search. Optionally, a specified number of search result entries may be displayed in conjunction with the displayed topics. By selecting one or more of the displayed topics, a user may be presented with those data corresponding to the selected topics. (Topics may, for example, be combined

through Boolean “and” and/or “or” operators.) In addition, the user may be presented with another list of topics based on the “new” result set in a manner described above. In summary, search operations in accordance with the invention respond to user queries by presenting a series of likely topics that most closely reflect the subjects that their initial search query relate to. Subsequent selection of a topic by the user, in effect, supplies additional search information which is used to refine the search.

Table 5. Example Query Result

For the data set identified in Tables 1, 3 and 4, a search on the single word “kidney” returns an initial result set comprising 147,549 hits. (That is, 147,549 segments had the word kidney in them.) Of these, 1,000 were chosen as a result subset. Using the specified thresholds discussed above, the following topics were represented in the result set: amino acid, dependent presence, amino terminal, kidney transplantation, transcriptional regulation, liver kidney, body weight, rat kidney, filtration fraction, rats treated, heart kidney, renal transplantation, blood pressure, and renal function. Selection of the “renal function” topic identified a total of 6,853 entries divided among the following topics: effects renal, kidney transplantation, renal parenchyma, glomerular filtration, loss renal, blood flow, histological examination, renal artery, creatinine clearance, intensive care, and renal failure. Selection of the “glomerular filtration” topic from this list identified a total of 1,400 entries. Thus, in two steps the number of “hits” through which a person must search was reduced from approximately 148,000 to 1,500 -- a reduction of nearly two orders of magnitude.

10 It is noted that retrieval operations in accordance with FIG. 6 may not be needed for all queries. For example, if a user query includes multiple search words or a quoted phrase that, using literal text-based search techniques,

returns a relatively small result set (e.g., 50 hits or fewer), the presentation of this relatively small result set may be made immediately without resort to the topic-based approach of FIG. 6. What size of initial result set that triggers use of a topic-based retrieval operation in accordance with the invention is a matter of design choice. In one embodiment, all initial result sets having more than 50 hits use a method in accordance with FIG. 6. In another embodiment, only initial result sets having more than **200** results trigger use of a method in accordance with FIG. 6.

One of ordinary skill in the art will recognize that various changes in the details of the illustrated operational methods are possible without departing from the scope of the claims. For example, various acts may be performed in a different order from that shown in FIGS. 1 through 7. In addition, usage statistics other than those disclosed herein may be employed to measure a word's (or a word combination's) actual usage in a targeted corpus of data. Further, query result display methods in accordance with FIGS. 6 and 7 may use selection thresholds other than those disclosed herein.

Referring to FIG. 8, acts in accordance with any, or a portion of any, of FIGS. 1 through 7 may be performed by a programmable control device executing instructions organized into one or more program modules **800**. In one embodiment, programmable control device comprises computer system **805** that includes central processing unit **810**, storage **815**, network interface card **820** for coupling computer system **805** to network **825**, display unit **830**, keyboard **835** and mouse **840**. In addition to a single processor system shown in FIG. 8, a programmable control device may be a multiprocessor computer system or a custom designed state machine. Custom designed state machines may be embodied in a hardware device such as a printed circuit board comprising discrete logic, integrated circuits, or specially designed Application Specific Integrated Circuits (ASICs). Storage devices, such as device **815**, suitable for tangibly embodying program module(s) **800** include all forms of non-volatile memory including, but not limited to: semiconductor memory devices such as

Electrically Programmable Read Only Memory (EPROM), Electrically Erasable Programmable Read Only Memory (EEPROM), and flash devices; magnetic disks (fixed, floppy, and removable); other magnetic media such as tape; and optical media such as CD-ROM disks.

5 While the invention has been disclosed with respect to a limited number of embodiments, numerous modifications and variations will be appreciated by those skilled in the art. It is intended, therefore, that the following claims cover all such modifications and variations that may fall within the true spirit and scope of the invention.

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